Description of Electrolytic Capacitors under Electrical Overstress Data Sets

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Experimental Description:

Three sets of 8 electrolytic capacitors (identified as **ES10**, **ES12, and ES14**) were continuously charged and discharged at a frequency of 100 mHz (50% duty cycle). Each set was charged to10,12, and 14 Volts respectively. Electrochemical Impedance Spectroscopy (EIS) measurements were performed using an SP-150 Biologic Potentiostat instrument. In addition, charge /discharge (Transient) waveform measurementsof each capacitor were recordedat 20Hz using National Instruments (NI) hardware and LabVIEWinterface. The EIS measurements as well as the transient voltage waveforms have been recorded in this dataset. Each dataset file (**ES10.mat**, **ES12.mat** or **ES14.mat**) has identical internal structures.

Files:

ES10.mat- Matlab data structure for all capacitors under electrical stress at 10 volts

ES12.mat - Matlab data structure for all capacitors under electrical stress at 12 volts

ES14.mat - Matlab data structure for all capacitors under electrical stress at 14 volts

Data Structure:

Each data structure (**ES10.mat, ES12.mat or ES14.mat)** contains two sub structures, **Transient_Data** (all recorded voltage data) and **EIS_Data** (all recorded EIS data); and a string, **Initial_Date**, which contains the date and time at which the aging began.

e.g.

```
>> ES10

ES10 =

      Transient_Data: [1x1 struct]
      EIS_Data: [1x1 struct]
      Initial_Date: '10/01/2014 10:00:00 AM'
```

Transient_Data

Transient_Data contains an array of structures used to identify the 8 capacitors**.**

e.g.

```
>> ES10.Transient_Data

ans =

     ES10C1: [1x1 struct]
     ES10C2: [1x1 struct]
     ES10C3: [1x1 struct]
     ES10C4: [1x1 struct]
     ES10C5: [1x1 struct]
     ES10C6: [1x1 struct]
     ES10C7: [1x1 struct]
     Serial_Date: [1x75826 double]
```

Also in **Transient_Data**, is **Serial_Date**, which is a 1x75826 matrix that contains the serial date corresponding to the date and time that each set of charge/discharge waveforms was recorded.

Each capacitor structure**(ES10C1, ES10C2, ES10C3, ES10C4, ES10C5, ES10C6, ES10C7** or **ES10C8)** contains 2 matrices.

VO - a 400x75826 matrix which contains the recorded voltages across the capacitor during its charge and discharge cycles

VL- a 400x75826 matrix which contains the recorded voltages across the load resistor during its charge and discharge cycles

e.g.

```
ES10.Voltage_Data.ES10C1

ans =

     VL: [400x75826 double]
     VO: [400x75826 double]
```

Each column represents a Transient measurement. The measurements were taken using developed NI hardware at a rate of 20Hz for 20 seconds every 100 seconds.Hence, there is a 50 ms interval between consecutive rows in the same column. The recording would then wait for 100 seconds before recording the next measurement(the nextcolumn).

EIS_Data

EIS_Data contains an array of structures used to identify the 8 capacitors.

e.g.

```
>> ES10.EIS_Data

ans =

    ES10C1: [1x1 struct]
    ES10C2: [1x1 struct]
    ES10C3: [1x1 struct]
    ES10C4: [1x1 struct]
    ES10C5: [1x1 struct]
    ES10C6: [1x1 struct]
    ES10C7: [1x1 struct]
    ES10C8: [1x1 struct]
```

A set of EIS measurements were taken for each capacitor multiple times each week and are recorded as a cell in **EIS_Measurement**. Each set contains the data generated in the SP-150 Biologic(instrument used to do EIS) data file. Within each **EIS_Measurement** you will find **Data**, **ColumnNames,** and **Header**.

Data- a cell structure that contains the recorded EIS data.On a given day, at least5 EIS measurements were taken per capacitor for a given EIS measurement.

ColumnNames- a string that contains the title for each column in Data.

Header- a cell structure that contains the header/support information for each EIS measurement.

e.g.

```
>>ES10.EIS_Data.ES10C1.EIS_Measurement(20)

ans =

    Header: {1x5 cell}
    Data: {1x5 cell}
    ColumNames: [20x12 char]
```

EIS_Reference_Table.mat is cell array of strings. The first column is the **Date** on which the EIS measurements were taken. The second and third columns represent the **Period** in which the capacitors have been aging. The forth column is the **Accumulated age**. This represents the total

time the capacitors have been aging for. The index of the row represents the equivalent **EIS_Measurement**.

Sample Plot

Figure 1 is a plot of the average Re(z) vsIm(z) for a given day. Below is the sample code used to generate the figure.

```
%Initialization of variables
Re = [];
Im = [];

%Loop to parse through the data
for a = 1:numel(ES10.EIS_Data.ES10C1.EIS_Measurement(20).Data)

%Concatenation of values of Real Impedance and Imaginary Impedance
    Re = [Re ES10.EIS_Data.ES10C1.EIS_Measurement(20).Data{1,a}(9:59,2)];
Im = [Im ES10.EIS_Data.ES10C1.EIS_Measurement(20).Data{1,a}(9:59,3)];

end

%Average of all the measurements
Re = mean(Re,2);
Im = mean(Im,2);

%Plotting function
figure(1)
plot(Re,Im);
xlabel('Re(z)','Fontsize',14)
ylabel('Im(z)','Fontsize',14)
title('Plot of Re(z) vsIm(z) for C1 | ES10','Fontsize',14)
```

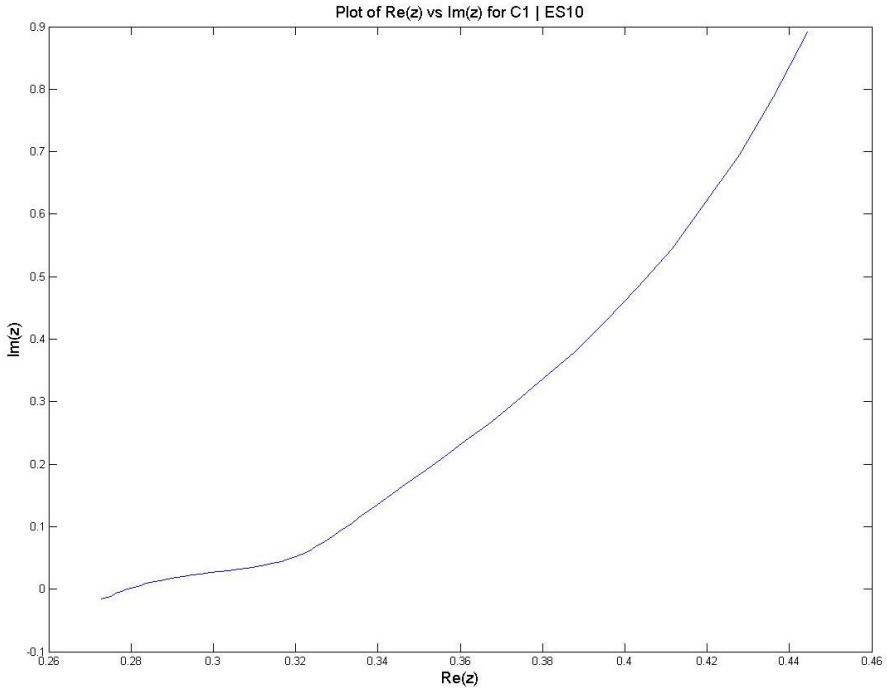

Figure 1: Average Re(z) vs Im(z)

Figure 2 is a plot of the transient waveforms. Below is the sample code used to generate the figure.

```
%Plotting function
figure(1)
plot(ES10.Transient_Data.ES10C1.VO(1:400,1:50:end))
xlabel('Time(ms/5))','Fontsize',14)
ylabel('Voltages)','Fontsize',14)
title('Plot of Voltage Waveform for C1 | ES10','Fontsize',14)
```

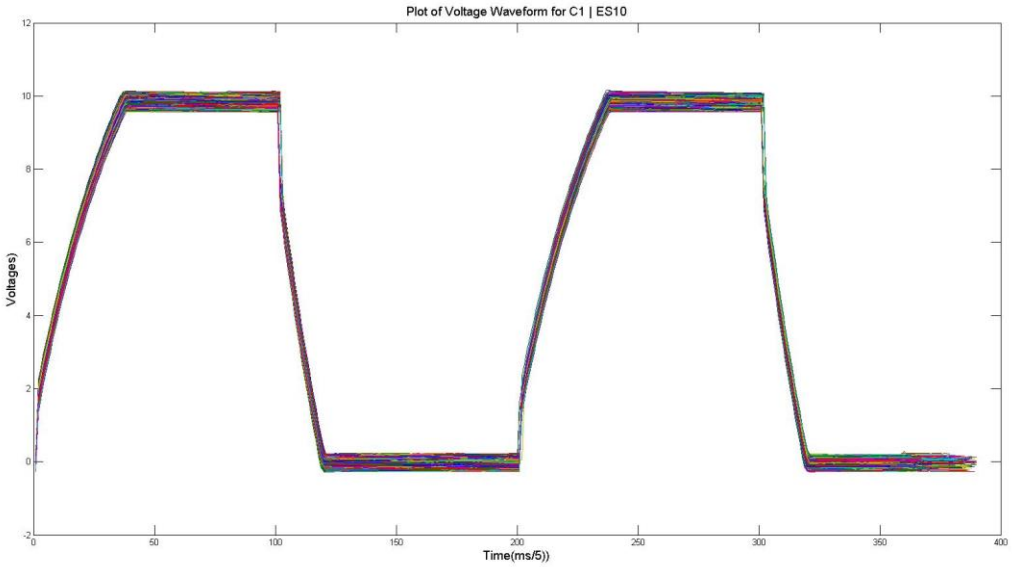

Figure 2: Voltage Waveform